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CIVIL ENGINEERS



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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, FEBRUARY 16, 1916,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Edward C. Sherman will present a paper, illustrated with lantern slides, on "The Spillways of the Panama Canal."

S. E. TINKHAM, *Secretary*.

PAPERS IN THIS NUMBER.

"Sand and Oil Roads and Surfaces," W. R. Farrington.

"Some Minor Problems in a Highway Bridge Design,"
L. M. Hastings.

"Pan-American Use of the Metric System," Fred. Brooks.

"Discussion of Federal Valuation of the Boston and Maine Railroad."

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Water Supply of Salem."	W. S. Johnson.	Jan.	March 10

Reprints from this publication, which is copyrighted, may be made provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

Members who wish to buy copies of the "surprise" provided by the Committee on Social Activities at the informal dinner on January 26 should notify the Editor at once. It will be typewritten or printed, depending on the number of copies ordered, and the cost ought not to exceed 10 cents a copy.

MINUTES OF MEETINGS.

BOSTON, MASS., January 26, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8.20 o'clock by the Senior Vice-President, Richard A. Hale. There were present 92 members and visitors.

By vote the reading of the record of the last meeting was dispensed with and it was approved as printed in the January JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership, in the grades named, the following candidates:

Members — Frank W. Johnson, Jacob M. Sokoll, Leslie W. Snow and Albert L. Upham.

Junior — Frank E. Peacock.

He also announced that the Board had elected to Honorary Membership, Past President Frederic Pike Stearns.

On motion of Mr. Harrison P. Eddy, it was voted that the Chair be requested to appoint a committee of three to suggest to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The Chair appointed, as that committee, Messrs. Louis F. Cutter, John C. Chase and Frederic I. Winslow. Later in the meeting that committee suggested the following names for members of the nominating

committee, and by vote they were elected: Messrs. Henry B. Wood, David A. Harrington, Henry T. Stiff, John L. Howard and Henry A. Varney.

The Secretary announced the deaths of the following members: Emory A. Ellsworth, died December 8, 1915; Thomas F. Richardson, died December 26, 1915, and S. Foster Jaques, died January 8, 1916. By vote the President was requested to appoint committees to prepare memoirs.

The chairman then introduced Mr. William R. Farrington, division engineer of the Massachusetts Highway Commission, who read a paper entitled, "Sand and Oil Roads and Surfaces."

The Secretary read communications from Mr. Austin B. Fletcher, highway engineer of the California Highway Commission; Mr. Charles M. Upham, chief engineer, Coleman du Pont Road, Inc., Georgetown, Del.; and Mr. Logan Waller Page, director, Office of Public Roads and Rural Engineering of the United States Department of Agriculture. Mr. W. P. Hammersley, superintendent of streets of New Bedford, also read a discussion of Mr. Farrington's paper, and Mr. John M. Keyes, road commissioner of Concord, Mass., discussed the paper briefly.

After passing a vote of thanks to Mr. Farrington for his very interesting paper, the Society adjourned.

S. E. TINKHAM, *Secretary*.

BINDING SOCIETY JOURNAL.

The Secretary has made arrangements for binding Volume II of the JOURNAL of the Society. The ten numbers will be bound in one volume, the style of binding to be uniform with that of last year. The price for this binding is 70 cents per volume.

Numbers for binding must be sent to 715 Tremont Temple, Boston, before March 1, 1916, in order to be bound at the price named.

APPLICATIONS FOR MEMBERSHIP.

[February 1, 1916.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BEAN, THOMAS WEBSTER, Turners Falls, Mass. (Age 29, b. So. Hadley Falls, Mass.) Graduate of Mass. Agricultural College, 1909, civil engineering course. From 1909 to 1911, with Warren H. Manning Co., Boston; from 1911 to date, civil engineer with Turners Falls Power and Electric Co.; in charge of topographical survey on Connecticut River between Turners Falls, Mass., and Vernon, Vt.; at present engineer on storage propositions. Refers to J. R. Baldwin, C. W. Hazelton, C. I. Hosmer and H. A. Moody.

BREEN, CHARLES HENRY, Ware, Mass. (Age 26, b. Ware, Mass.) Student for two years in civil engineering course at Case School of Applied Science, Cleveland, Ohio, and for two years at Mass. Inst. of Technology; graduate of latter institution, 1912. From 1912 to date, with exception of three months with Mass. Highway Comm. and private engineer, has been employed by Mass. Harbor and Land Comm., with which commission he now holds position of transitman. Refers to C. F. Allen, L. H. Bateman, C. B. Breed, C. M. Spofford, W. F. Williams and H. B. Wood.

CROSS, RALPH UPTON, Tufts College, Mass. (Age 23, b. Worcester, Mass.) Student, Tufts College Engineering School. During past six summer vacations has worked for E. J. Cross Co., of Worcester, on building construction. Refers to H. P. Burden, S. L. Conner, E. H. Rockwell, F. B. Sanborn and R. C. Smith.

FARRELL, FRANCIS BERNARD, Roxbury, Mass. (Age 33, b. Kentville, Nova Scotia.) Graduate of Worcester Polytechnic Inst., 1915, civil engineering course, degree of B.S. During vacations and previous to college course, worked for such firms as J. W. Bishop Co., H. L. Hemenway Co., and B. W. Neil of Brookline, on construction work; since graduation has been with Stone & Webster Engrg. Corp'n on new Technology buildings. Refers to H. M. Allen, B. S. Brown, A. W. French, A. J. Knight and F. B. Sanborn.

HOOD, RALPH DUTTON, Haverhill, Mass. (Age 41, b. Topsfield, Mass.) Educated in public schools and at Phillips Andover Academy. From 1890 to 1892, rodman, draftsman and transitman; from 1893 to 1895, surveyor for various public service works; from 1895 to 1896, location engineer, Haverhill, Georgetown & Danvers St. Ry.; from 1897 to 1899, chief engineer, Franklin Construction Co.; from 1899 to 1902, with Massachusetts Construction Co.; during 1903, chief engineer, National Construction Co.; from 1904 to 1905, office engineer, El Paso and Durango; during 1906, engineer, New England Breeders' Club; during 1907, with National Railway Construction Co.; from 1908 to 1910, engineer with New Hampshire El. Rys. Co.; during 1911, superintendent of highways, Haverhill; during 1913, with Municipal Council, Haverhill Department of Streets and Highways; from 1914 to date, engineer, maintenance of way, Mass. Northeastern St. Ry. Co. Refers to A. W. Dean, R. R. Evans, Gilbert Hodges and A. D. Marble.

LEWIS, GEORGE WALLACE, Boston, Mass. (Age 26, b. Waltham, Mass.) Graduate of Harvard College, 1910, degree of B.S. From 1910 to date, engineer with Hugh Nawn Contracting Co. Elected a Junior June 21, 1911, and now desires to be transferred to grade of Member. Refers to C. T. Fernald, Hugh Nawn, L. L. Street and W. O. Wellington.

LUTHER, ROYAL, Portland, Me. (Age 61, b. Fall River, Mass.) Received technical education from private teachers and at evening school, these studies being supplemented by practical experience as helper at various mechanical trades and apprenticeship of several years to contractor and builder. From 1875 to date, with U. S. Lighthouse Service; in which service he now holds position of superintendent; among important works with which he has been identified are the Graves Lighthouse, Boston Bay, Mass.; and Ram Island Ledge, Portland Harbor, Me. Refers to E. P. Adams, T. T. H. Harwood, F. E. Tibbetts, G. H. Towle, J. H. Wallace and H. E. Warren.

PEABODY, DEAN, JR., Reading, Mass. (Age 27, b. Reading, Mass.) Graduate of Mass. Inst. of Technology, 1910, degree of S.B., mechanical engineering course. From September, 1910, to June, 1913, assistant instructor in mechanical engineering, and from June, 1913, to date, instructor in applied mechanics and testing materials, Mass. Inst. of Technology; during summer of 1911, timekeeper for Aberthaw Construction Co.; summer of 1912, draftsman with New England Concrete Construction Co.; summer of 1913, draftsman with Lockwood, Greene & Co.; summer of 1914, draftsman with Stone & Webster Engrg. Corp'n. Refers to H. W. Hayward, A. B. MacMillan, E. F. Miller and W. H. Sears.

TURNER, JOHN MATHES, Brookline, Mass. (Age 19, b. Mobile, Ala.) Student at Y. M. C. A. evening school during winter of 1912-13; since September, 1914, has been student at Lowell Inst., buildings course. From July 1, 1912, to date, with Brookline Engrg. Dept., as rodman and transitman. Refers to W. A. Devine, H. W. French, H. W. Hayward, F. A. Leavitt, H. A. Varney and C. J. Wallace.

WHITNEY, RALPH EDWARD, Boston, Mass. (Age 25, b. Keene, N. H.) Graduate of Dartmouth College, 1912, degree of B.S., and of Thayer School of Civil Engrg., 1913, degree of C.E. From May, 1913, to date, draftsman and resident engineer on construction with Robert Spurr Weston. Refers to J. M. Cashman, A. L. Gammage, F. L. Preble, G. A. Sampson, J. P. Wentworth and R. S. Weston.

LIST OF MEMBERS.

ADDITIONS.

ALEXANDER, CLAYTON C.....	Mt. Auburn Cemetery, Cambridge, Mass.
BIGELOW, LYMAN W.....	Rm. 15, Bigelow Block, Norwood, Mass.
BURLEIGH, WILLARD G.....	20 Chandler St., Waverley, Mass.
DUGGAN, JOSEPH R.....	1 West St., Milford, Mass.
HASTIE, FRANK B.....	1067 Beacon St., Brookline, Mass.
PITCHER, SAMUEL H.....	418 Main St., Worcester, Mass.

CHANGES OF ADDRESS.

BROWN, T. MORRIS.....	600 Main St., East Orange, N. J.
CUMMINGS, W. WARREN.....	15 Winter St., Woburn, Mass.
FARLEY, WM. F.....	249 Bacon St., Waltham, Mass.
JERRETT, ROBERT.....	103 Whitmarsh St., Providence, R. I.
JOY, C. FREDERICK, Jr.....	61 Shurtleff St., Chelsea, Mass.
KNOWLTON, ARTHUR W.....	25 Beach St., Rockport, Mass.
LOUD, RALPH W.....	427 Broadway, Cambridge, Mass.
MORRILL, FRED W., Care of Ferro Concrete Construction Co., Cincinnati, Ohio	
PIERCE, CHARLES H.....	Custom House Bldg., Boston, Mass.
ROBINSON, HAROLD L.....	103 June St., Worcester, Mass.

DEATH.

JAKES, S. FOSTER.....	Jan. 8, 1916
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EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

316. Age 29. Student for three years in civil engineering courses at Harvard Univ.; student in evening courses in mechanical and electrical engineering at Mass. Inst. of Technology. Is junior member of Am. Soc. C. E. and associate member of Am. Inst. E. E. Experience includes one year as transitman of Metropolitan Water and Sewerage Bd. and six years on electric railway work as draftsman, chief of party, resident engineer, superintendent of underground construction, etc. Desires position in line with this experience.

329. Age 23. Graduate of Mass. Inst. of Technology, 1914, civil engineering course. Experience consists of four months as building inspector with American Tel. & Tel. Co., and fourteen months with U. S. Coast and Geodetic Survey on hydrography, leveling, plotting, etc. Desires position with railroad contractor or consulting engineer. Salary desired, \$75 per month.

344. Age 22. Graduate of Manual Training High School, New Orleans, La.; student for three years at Tulane University, New Orleans, and for one year at Mass. Inst. of Technology. Has had three months' experience in valuation department of Boston & Albany R. R. Desires position as rodman or chainman. Salary desired, \$65 per month.

345. Age 22. Student for two years at Boston Y. M. C. A. Co-operative Engineering School. Has had over two and one-half years' experience as rodman and transitman. Desires position along engineering lines. Salary desired, \$15 per week.

347. Age 23. Graduate of Worcester Polytechnic Inst., degree of B.S., civil engineering course. Has had over a year's experience in designing and estimating for civil engineering firm; experience also includes drafting and surveying. Desires position as designer or estimator; is especially interested in concrete and steel work. Salary desired, \$75 per month.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Production of Abrasive Materials in 1914. Frank J. Katz.
Manufacture and Uses of Alloy Steels. Henry D. Hibbard.
Annual Report of Director of Bureau of Mines for 1914-15.
Annual Report of Interstate Commerce Commission for
1915, Part I.

Annual Report of Superintendent of Coast and Geodetic
Survey for 1914-15.

(The) Ashes: Their Characteristics and Management. W.
D. Sterrett.

Production of Asphalt, Related Bitumens, and Bituminous
Rock in 1914. John D. Northrup.

Broad Pass Region, Alaska. Fred H. Moffit.

Statistics of Clay-Working Industries in United States in
1914. Jefferson Middleton.

Preliminary Report on Diffusion of Solids. C. E. Van Or-
strand and F. P. Dewey.

Ellamar District, Alaska. S. R. Capps and B. L. Johnson.

Erosion Intervals in Eocene of Mississippi Embayment.
Edward Wilber Berry.

Evaporation of Potash Brines. W. B. Hicks.

Production of Feldspar in 1914. Frank J. Katz.

Gems and Precious Stones in 1914. Douglas B. Sterrett.

Gold, Silver, Copper, Lead, and Zinc in California and Ore-
gon in 1914. Charles G. Yale.

Gold, Silver, Copper, Lead, and Zinc in Colorado in 1914.
Charles W. Henderson.

Notes on Geology of Gravina Island, Alaska. Philip S.
Smith.

Iron Ore in Cass, Marion, Morris, and Cherokee Counties,
Texas. Ernest F. Burchard.

Iron-Bearing Deposits in Bossier, Caddo and Webster
Parishes, Louisiana. Ernest F. Burchard.

Age of Ocala Limestone. Charles Wythe Cooke.

Production of Magnesite in 1914. Charles G. Yale and Hoyt S. Gale.

Methods for Examination of Bituminous Road Materials. Prévost Hubbard and Charles S. Reeve.

Results of Observations Made at Coast and Geodetic Survey Magnetic Observatory at Cheltenham, Maryland, 1913 and 1914.

Statement made by Secretary of War to Committee on Military Affairs of House of Representatives, 1916.

Secretary of War Garrison's Explanation of Military Policy Recommended by him and Approved by President.

Modern Soldier Cannot be Made in a Day. Henry Breckinridge.

Potash in Certain Copper and Gold Ores. B. S. Butler, Ed.

Portland Cement Materials and Industry in United States. Edwin C. Eckel.

Production of Platinum and Allied Metals in 1914. James M. Hill.

Quicksilver Deposits of Mazatzal Range, Arizona. F. L. Ransome.

Reconnaissance in Kofa Mountains, Arizona. Edward L. Jones, Jr.

Rhode Island Coal. George H. Ashley.

Trenching Machinery Used for Construction of Trenches for Tile Drains. D. L. Yarnell.

Water Power Projects, Telephone, Telegraph, Power Transmission Lines on National Forests.

Water-Supply Papers 354, 355, 358, 370, 373, 376-379, 388.

Willow Creek District, Alaska. Stephen R. Capps.

Willows: Their Growth, Use and Importance. George N. Lamb.

State Reports.

Massachusetts. Annual Report of Public Service Commission for 1915 (advance copy).

Massachusetts. Reports of Directors of Port of Boston as follows: In re Dry Dock, 1915; Use and Benefits to Massachusetts Manufacturers and Wage Earners of American Merchant Ma-

rine, 1915; Analysis of Present Foreign Trade of United States, 1916.

New Jersey. Annual Report of Board of Health for 1914.

New York. Report of State Department of Health on Disposal of Human Excreta and Sewage of Country Home, 1915.

West Virginia. Wood-Using Industries, 1914. J. C. Nellis and J. T. Harris.

Wisconsin. Geography of Fox-Winnebago Valley. Ray Hughes Whitbeck.

Municipal Reports.

Detroit, Mich. Annual Report of Department of Parks and Boulevards for 1915.

Hartford, Conn. Annual Report of Water Commissioners for 1914-15.

Providence, R. I. Annual Report of Department of Public Works for 1915.

Salem and Beverly, Mass. Annual Report of Water Supply Board, June, 1913, to September, 1915.

Miscellaneous.

American Institute of Mining Engineers: Transactions for 1915, Vol. LI.

American Society of Civil Engineers, Transactions for 1915, Vol. LXXIX, 1915.

Berger Mfg. Co.: Fire, Water and Load Tests on Berger's Metal Lumber System.

General Specifications for Concrete Work. Wilbur J. Watson. Gift of McGraw-Hill Book Co.

Master Car Builders' Association: Proceedings for 1915, 2 vols.

National Board of Fire Underwriters: Report on Congested Dwelling and Tenement Districts in Cities and Towns in Massachusetts; Reports on following cities: Albany, N. Y.; Amsterdam, N. Y.; Atlantic City, N. J.; Battle Creek, Mich.; Bay City, Mich.; Bayonne, N. J.; Bridgeport, Conn.; Brockton, Mass.; Buffalo, N. Y.; Cedar Rapids, Ia.; Chester, Pa.; Cincinnati, O.; Decatur, Ill.; Des Moines, Ia.; Erie, Pa.; Fall River, Mass.;

Fresno, Cal.; Green Bay, Wis.; Harrisburg, Pa.; Haverhill, Mass.; Kalamazoo, Mich.; Lawrence, Mass.; Louisville, Ky.; Lowell, Mass.; Lynn, Mass.; Malden, Mass.; Manchester, N. H.; Nashville, Tenn.; New Bedford, Mass.; North Tonawanda, N. Y.; Norwich, Conn.; Peoria, Ill.; Pittsburgh, Pa.; Portsmouth, Va.; Providence, R. I.; Roanoke, Va.; Rochester, N. Y.; Rockford, Ill.; Saginaw, Mich.; San Francisco, Cal.; Springfield, Ill.; Troy, N. Y.; Williamsport, Pa.; Wilmington, Del.

National Electric Light Association: Handbook on Overhead Line Construction; Proceedings for 1915, Hydro-Electric and Transmission and Technical Sessions; Proceedings for 1915, New England Section. Gift of W. B. Conant.

New International Encyclopædia, Vols. 17 and 18.

Principles and Practice of Surveying, 2 vols. Charles B. Breed and George L. Hosmer. Gift of the authors.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work is in progress on Sects. 104 and 106, the Wellesley extension sewer; and on Sect. 1A, the outfall sewer at Deer Island.

Work contemplated includes Sect. 103, Wellesley extension sewer, for which contract has been awarded and on which work will be started March 1, and other sections of the Wellesley extension.

METROPOLITAN PARK COMMISSION.—The following work, in addition to that reported in the January JOURNAL, is in progress:

Old Colony Parkway.—Plans are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old Neponset Bridge.

Boston Transit Commission. — *Dorchester Tunnel.* — Descriptions of Sections D, E, G and H were printed in the JOURNAL in October and December, 1915.

No change is reported in the status of Section D.

In Section E both shields are under the channel, the one for the easterly tunnel being several hundred feet in advance of that for the westerly tunnel.

On Section G, excavation by tunneling for the 3 ft. by 5 ft. and 4 ft. 9 in. by 5 ft. 6 in. intercepting sewer in Dorchester Ave. is completed for a length of about 400 ft., or for about two thirds of the total length. About 60 lin. ft. of the lower half of the reinforced concrete sewer is in place.

Excavation for the pump well at B St. and for the incline between West Fourth and B Sts. in Dorchester Ave. is completed.

Excavation has been started, west of the incline, for the main tunnel, the bottom of which is to be about 43 ft. below the surface of the street. Tongued and grooved sheeting is being driven.

The excavation for Section H has been practically finished. The construction of the tunnel has been substantially completed with the exception of about 50 ft. at the southerly end of the section, a pump well at D St. and a ventilating chamber and emergency exit near Woodward St.

City of Boston. — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Construction work has been suspended on account of unfavorable weather.

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

SAND AND OIL ROADS AND SURFACES.

BY W. R. FARRINGTON,* M.Am.Soc.C.E.

(Presented January 26, 1916.)

THE first sand and oil road in this state was constructed by the Massachusetts Highway Commission on Cape Cod, in the town of Eastham, in 1905. In constructing this road, the California method was first followed, but before its completion the so-called "layer method" was adopted.

Some experiments were made with mixed sand and oil for road surfaces in 1908, but the first mixed sand and oil surfaces of any extent were laid in Wareham and Rochester, in 1909. The layer sand and oil roads have therefore been in use in this state for some ten years, and the mixed sand and oil surfaces for six years.

LAYER ROADS.

In constructing the road in Eastham, as stated, the California method was first followed. The old road surface, consisting principally of sand of various grades, was roughly shaped and about $\frac{3}{4}$ gal. of hot oil applied per sq. yd. The oil used was similar to that used for hot blankets on macadam or gravel. A

NOTE. Discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before April 10, 1916, for publication in a subsequent number of the JOURNAL.

* Division Engineer, Mass. Highway Comm., Middleborough, Mass.

week or ten days later, a second $\frac{3}{4}$ -gal. application of oil was made and the road again harrowed. It was then opened to travel, and eventually covered with a light coating of sand and rolled with a horse roller.

It is probably of interest to note that the distributor used, a large pipe with perforations and sleeve with similar perforations so mounted that it could be revolved and thus vary the size of the openings through which the oil passed, did not apply the oil in a film, but in streaks. Also, the horse-drawn distributor wagon cut the surface badly, causing the oil to settle in the wheel tracks and depressions formed by the horses' feet. The oil was allowed to stand several days, and was then mixed with the sand by a thorough harrowing with a disk harrow.

The construction of this road, and of a similar road in the adjoining town of Orleans, demonstrated, however, that this method was not economical and did not give the best results. Various experiments were made and the "layer method" finally evolved, the roads being completed by this method. It is understood that, with the soil found in those sections of California where the so-called sand and oil roads were constructed quite extensively some years ago, good results are obtained through mixing the oil with the soil by harrowing and by rolling with a tamping roller, provided the road is kept saturated with water during the process. However, to obtain the best results with the sand found in this region, especially on Cape Cod, a different treatment is required.

In constructing a road by the layer method, the subgrade is shaped and any sandy places hardened. Either $1\frac{1}{2}$ gals. of hot oil in two applications, or 2 gals. in three applications, are put on. Sand is spread over the oil after each application, and the road rolled with a horse roller, it being well to do the final rolling with a steam roller, if one is available.

With the $\frac{3}{4}$ -gal. application of oil, about $1\frac{1}{2}$ ins. of sand are used for covering; and with the $\frac{2}{3}$ -gal. application, about $1\frac{1}{4}$ ins. The $1\frac{1}{2}$ -gal. treatment should give eventually a thickness of about $3\frac{1}{2}$ ins., and the 2-gal. treatment, about 4 ins.

If it is desired to confine to one season all work on the road properly chargeable to construction, 2 gals. of oil should be used,

otherwise it is advisable to use only $1\frac{1}{2}$ gals. the first season and to apply another $\frac{1}{2}$ gal. the following spring. Experience has demonstrated that any surface constructed of sand and oil by the layer method will be more or less out of shape for some time after the oil is applied, and that weak places will develop. It is principally for this reason that it is more satisfactory and economical to delay the application of the last $\frac{1}{2}$ gal. of oil until the second season. By this method it is possible to find and strengthen any weak places and to remove any inequalities in the surface by scraping with a road machine before the final application of oil.

The heavier grades of oil used for hot blankets are suitable for sand and oil layer work. Some oils with a viscosity as low as 200 seconds,* and others with a viscosity of 845 seconds, have given good results, but usually an oil having a viscosity of from 500 to 600 seconds will give the best results. The specific gravity should be between .98 and 1.00 at 25 degrees C.

A clean, sharp and fairly coarse sand will give the best results, but a comparatively fine sand, even one containing a small proportion of clay or loam, will give good results with the proper grade of oil. Tests made of the sand used on layer work in various places show that the finest sand was such that 24 per cent. passed a 50-mesh screen and only 4 per cent. was retained on an 8-mesh screen, whereas of the coarsest sand 12 per cent. was retained on an 8-mesh screen and only 18 per cent. passed a 50-mesh screen.

The oil should be applied by a distributor which will spread it evenly over the surface. The best results are obtained by the use of a pressure distributor, and usually a horse-drawn machine is preferable to a motor truck, since the ordinary subgrade will not carry a truck without rutting and breaking up. The oil should be shipped and heated in tank cars, but it is advisable to have the distributor carts equipped with steam coils or oil burners, so the oil can be heated in the carts if necessary.

* In all cases where the viscosity is referred to, the number of seconds given is with the Lawrence Viscosimeter at 100 degrees C. As a basis of comparison, it is to be noted that 100 sec. with the Lawrence Viscosimeter at 100 degrees C. equal approximately 173 sec. with 100 cc. Engler Viscosimeter.

For hardening the subgrade, sandy loam or clay is ordinarily used, two or three inches of either material being sufficient to carry the travel while the surface is being formed. Gravel is preferable, as this will add strength to the surface, but suitable gravel is usually not obtainable in those sections where the sand and oil roads have been constructed by the layer method, and if it is obtainable it is probably advisable to substitute bituminous gravel for the sand and oil.

The surface of a sand and oil road constructed by the layer method should have a crown of not over $\frac{1}{2}$ in. to the foot, and should be at least 15 ft. wide; from 16 ft. to 18 ft. is a more satisfactory width unless the shoulders are hardened, as, if there is any considerable amount of turning out on to soft shoulders, the edges of the sand and oil will be broken down rapidly.

The cost of the surface of sand and oil roads constructed by the layer method has varied from 21 cents to 33 cents per sq. yd., the average cost being 26 cents per sq. yd. This cost does not include grading, culvert work, etc., but does include shaping the subgrade. The average yearly cost of maintenance of the first section constructed in Eastham has been 2 cents per sq. yd., and of other roads constructed at least five years, 1 cent per sq. yd.

MIXED SAND AND OIL SURFACES.

In constructing mixed sand and oil surfaces, the materials were mixed by hand until the fall of 1912. Since then a mechanical mixer has been used with excellent results. The mixer used thus far is an ordinary cube concrete mixer, operated by steam and equipped with a charging device and heating attachment which consists of an oil burner, with air blast, throwing the flame into the mixer. The part with which the flame comes in contact is lined with firebrick.

Previous to the spring of 1915 the sand was heated with the old-fashioned pipe or arch heaters. During the past season a revolving drum heater with oil burners has been used with fairly good results. There is no doubt that such a heater when perfected, as it presumably will be in the near future, will prove economical and will be used extensively. It is somewhat similar

to the drum used with an asphalt plant, but the drum is not enclosed, and the flame is thrown directly into one end. There are blades or flanges bolted to the inside of the drum which carry the sand to the top, whence it falls through the hot blast from the burners. The drum is inclined so as to carry the sand slowly to the lower end.

The use of an asphalt plant on sand and oil work has been considered, but the cost of such an outfit and the cost of transportation have been considered prohibitive on work of this nature.

In constructing a mixed sand and oil surface, the subgrade is shaped, and if sandy is hardened with the best material available, usually sandy loam or clay. The sand and oil are heated to the proper temperatures and mixed by hand or by machine. If by hand, the mixing is done on platforms with rakes and hoes, or by turning with shovels. The mixing is continued until all the grains of sand are coated with oil. For this work, from 15 to 25 gals. of oil or oil asphalt have been used per cubic yard of loose sand, but ordinarily the best results have been obtained by the use of about 16 gals. per cu. yd. of sand if loose, or about 18 gals. if compacted. To obtain satisfactory results, the sand must be dry as well as hot. If the sand in the pit when used is fairly dry, it can be mixed in a hot mixer without preliminary heating, but this is not economical, as from five to six minutes are required to mix a batch thoroughly, whereas with hot sand the mixing can be done in about two minutes. The oil, before mixing with the sand, is heated in kettles or tanks to a temperature of from 250 degrees fahr. to 375 degrees fahr., depending on its nature.

The sand and oil mixture is immediately carted to the road and spread, usually in one course, although under some conditions spreading in two courses may be preferable. The mixture is shaped with rakes and immediately rolled. A horse roller is used for the preliminary rolling, but the surface should be rolled with a tandem steam roller in the course of a few hours. The length of time which should elapse before using the tandem roller depends on the temperature and general weather conditions, but ordinarily any material placed in the morning can be

rolled in the afternoon of the same day. During the rolling with steam roller the surface is reshaped with a road machine which removes any inequalities developed during the preliminary rolling. The results obtained on roads not shaped with a suitable scraper during rolling have shown that this work is necessary if the best results are to be obtained on mixed sand and oil work. It is not advisable to use a steam roller for the preliminary rolling, as it tends to force the mixture out of shape when fresh, and to produce an uneven and wavy surface.

Various grades of oils and oil asphalts have been used on mixed sand and oil work, from a hot oil similar to that used for hot blankets, having a viscosity of about 200 seconds, Lawrence Viscosimeter, at 100 degrees C., to oil asphalts having a penetration of from 60 to 150, Dow Penetrometer, at 25 degrees C. Under ordinary conditions, however, the best results have been obtained with oil asphalt having a penetration of from 90 to 125.

If the grains of sand are rounded, and especially if the sizes of the grains vary little, as with ordinary beach sand, a very heavy oil asphalt gives the best results, whereas with sharp sand, well graded, and containing a considerable proportion of grains which will not pass a screen with $\frac{1}{8}$ -in. mesh, an oil having a viscosity of from 800 to 1 700 seconds, Lawrence Viscosimeter, at 100 degrees C. gives good results.

Tests made with sand from different pits used for mixed sand and oil work in this state show that of the finest sand used with good results 51.6 per cent. passed a 50-mesh and only 3.6 per cent. was retained on an 8-mesh screen, whereas of the coarsest sand 35.3 per cent. was retained on an 8-mesh and only 11.9 per cent. passed a 50-mesh screen.

It is evident that a fairly coarse sharp sand, the particles of which are well graded, gives the best results. It is also true that a comparatively fine sand, if the grains are sharp and not all of one size, gives satisfactory results, although a heavier oil is required. The coarse sand will probably carry heavier traffic and wear longer.

It is probable that small amounts of clay or loam are not objectionable, but since any large percentage of these materials is detrimental to the work, their use should not be allowed ex-

cept possibly where the only sand available does not contain a sufficient amount of fine grains to give the proper grading.

The addition of from 5 to 10 per cent. of cement gives a more dense and stronger mixture, but of course increases the cost. Cement has not as yet been used on this work long enough to determine whether the results warrant the additional cost.

While it is possible to construct a mixed sand and oil surface on sand without hardening the subgrade, provided the mixture is spread in two courses, it has been proved that this is not economical and that the results are not satisfactory unless the thickness is increased. The subgrade will be cut up by the teams used on the work and the sand mixed with the surface during the rolling, causing weak places and an uneven surface. Also, the thickness will not be uniform and the surface will naturally be only as strong as the weakest sections. Moreover, if the subgrade is not hardened, the cost of shaping and rolling will be considerably increased, since to obtain good results it is necessary that the surface of the lower course be reasonably smooth before the second course is spread, as any considerable inequalities in the lower course will be reproduced eventually in the finished surface of the road.

After the sand and oil mixture has been thoroughly rolled, the surface is sealed by the application of hot oil having a viscosity of from 250 to 600 seconds, Lawrence Viscosimeter, at 100 degrees C. at the rate of $\frac{1}{2}$ gal. per sq. yd. The oil is spread by a pressure distributor in two $\frac{1}{4}$ -gal. applications, each followed by a light covering of sand. This coat not only seals the surface of the mixed sand and oil but also adds about $\frac{1}{2}$ in. to the thickness.

A mixed sand and oil surface should have a crown of not over $\frac{1}{2}$ in. to the foot, and should be not less than 18 ft. wide, since with mixed sand and oil, even more than with a surface constructed by the layer method, the edges will be rapidly broken down if there is any considerable amount of driving from the sand and oil surface on to the shoulders. The thickness should be from $3\frac{1}{2}$ to 4 in. before the seal coat is applied.

The cost of mixed sand and oil surfaces, including the seal coat, has varied from 40 cents to 61 cents per sq. yd., the average

TABLE OF OIL TESTS.

Town.	OIL USED FOR MIXING.					OIL FOR SEAL COAT.				
	Sp. Gravity.	Penetration, 25° C.	Insol. Car. Bis.	Insol. 88 B. Naphtha.	Evap. 5 Hrs. at 325°.	Sp. Gravity.	Viscosity 100° Lawrence Viscosimeter.	Insol. Car. Bis.	Insol. 88 B. Naphtha.	Evap. 5 Hrs. at 325°.
Bourne, E., 1914	1.02	135	1.2	23.4	0.5	1.00	530	0.1	18.5	3.1
	1.03	118	0.1	23.1	0.4					
Mashpee { 1912	.995	125	0.0	23.0	6.4*	.985	700	1.0	19.1	16.5*
1913	1.01	150	0.6	27.8	13.2					
Plymouth { 1912	.995	110	0.0	21.5	2.4*	.997	660	0.1	17.1	13.1
1913	1.03	118	0.1	22.7	0.3					
Provincetown, 1914										
Sandwich { 1912	1.00	100†	1.7	18.5	0.2*					
1913	1.00	150	0.2	26.7	10.7					

* Evaporation 12 hrs. at 250 degrees.

† Penetration at 20 degrees C.

TABLE OF SAND TESTS.

	LAYER METHOD.		MIXED SAND AND OIL.				
	Eastham, 1909. Stand. A.	Harwich, No., 1908. Stan. A.	Plymouth, 1913. Stan. B.	Bourne, E., 1914. Stan. B.	Bourne, E., 1914. Stan. C.	Mashpee, 1913. Stan. B.	Sandwich, 1912. Stan. B. Hand Mixed.
Passing 200 Mesh	1.5	5.2	1.5	1.5	1.2	2.2	7.2
100	2.0	3.3	3.2	2.9	2.6	1.0	14.7
80	2.3	2.8	3.2	3.5	1.8	1.8	9.5
50	12.5	12.1	18.6	19.4	6.3	11.2	20.2
40	8.6	12.7	9.9	7.3	2.8	9.4	8.9
30	14.3	18.1	19.5	18.2	7.6	15.4	11.4
20	20.3	26.5	20.1	18.1	14.7	22.3	13.9
10	23.0	15.1	12.8	13.0	21.4	21.6	9.1
8	4.0	1.1	1.4	2.6	6.3	3.2	1.5
4	11.5	3.1	9.8	4.3	12.1	11.9	3.6
2				9.1	13.7		
Retained 2					9.5		
SUMMARY							
Passing 50 Mesh	18.3	23.4	26.5	27.3	11.9	16.2	51.6
Retained 8 Mesh	11.5	3.1	9.8	13.4	35.3	11.9	3.6

being 52 cents. This cost is for the surface alone and does not include grading, culvert work, etc. The average yearly cost of maintenance for those roads which have been in use at least five years is 1.6 cents per sq. yd., and for those in use three years $\frac{3}{4}$ cent per sq. yd.

The first mixed sand and oil surfaces were not sealed when constructed, but a seal coat was applied a year or two later. None of the roads have as yet been resealed, but a seal coat will probably have to be applied once in four or five years at a cost of about 6 cents per sq. yd. If so, this will increase the yearly cost of maintenance to about $2\frac{1}{2}$ cents per sq. yd.

TRAFFIC.

The amount of traffic a sand and oil road will safely carry is as yet somewhat problematic. It is probable that there has been no instance in this state where a sand and oil road of either type has failed, if properly constructed of suitable material. On the other hand, the layer roads have been constructed only in those sections where the travel is comparatively light, and none of the mixed surfaces have been subjected to any very large amount of heavy traffic.

It is true that some heavy loads have passed over both types of roads, as, for instance, in the transportation of bituminous materials by motor trucks weighing, with load, about 14 tons, but the number of such loads in any one season has been small. Under these loads the layer roads have shown some evidences of weakness, but there has been no indication of failure with the mixed surfaces. That neither road will carry a large amount of horse-drawn traffic alone is evidenced by the fact that such surfaces have in several instances been badly cut up by the passage of a troop of cavalry or a large number of transport wagons during army maneuvers, but this is also true of either hot or cold blankets on macadam.

It has also been observed that a mixed sand and oil surface which has carried successfully quite a heavy traffic during the summer, when the proportion of motor travel was comparatively large, has been considerably cut up in the spring before the motor traffic season commenced, although evidently the actual number

of horse-drawn vehicles was much less in the spring than during the summer.

It seems probable, from the experience thus far gained with sand and oil roads in this state, that the layer road will carry only a light traffic and is a suitable type of road only where the conditions will not warrant a more expensive surface. Aside from the amount of traffic a layer road will carry, it is probably impossible to obtain by this method as satisfactory a surface as by the mixed method. However, if the travel is light, not only can a surface be constructed at a comparatively small cost by the layer method, but such a surface can be economically maintained.

A mixed sand and oil surface will probably carry quite a heavy traffic, provided the proportion of horse-drawn vehicles is not excessive, but presumably not so heavy as bituminous macadam or bituminous gravel. While the mixed sand and oil surfaces have been very satisfactory on Cape Cod and in other sections where the travel and conditions are similar, it has not been considered advisable, thus far, to construct these surfaces where there is a considerable amount of heavy traffic, provided broken stone of a satisfactory quality or material suitable for bituminous gravel can be obtained at a reasonable cost. Experiments are being made, however, with different grades of sand and different bituminous materials, and it is probable that some combination will be found which will give a denser mixture and a firmer surface, one which will carry heavier loads and stand up better under horse-drawn traffic than the ordinary mixed sand and oil surface. To obtain this result it may be necessary to vary the grading of the sand found in the ordinary pit by combining the finer with the coarser grades, or by the addition of cement. It is also probable that a heavy asphalt, or oil asphalt, will have to be used. If such a mixture can be obtained at a reasonable cost, it will be possible, by the use of a 3-in. or 4-in. base of the ordinary mixture with a 2-in. or 2½-in. wearing surface of the denser mixture, to construct a surface of sand and asphalt, or oil asphalt, which will carry heavy traffic economically and will compare favorably with bituminous gravel or bituminous macadam.

BITUMINOUS GRAVEL.

While it is probably not within the province of this paper to consider bituminous gravel surfaces in detail, a brief mention of them would seem pertinent since these surfaces have been developed in connection with the sand and oil work, and the methods followed in their construction are similar.

In constructing these surfaces, gravel is spread on the subgrade to a depth sufficient to give 4 or 5 in. after rolling, the gravel being watered and thoroughly compacted with a steam roller. The top course or wearing surface consists of a mixture of oil, or oil asphalt, and gravel $2\frac{1}{2}$ ins. thick after rolling, this also being compacted with a steam roller. Either a tandem or a regular macadam roller can be used, but the former is preferable. Rather more bituminous material is used for mixing than with sand and oil work, but not over 20 gals. per cu. yd. of gravel should be required. With this surface a seal coat is not necessary.

The best results are obtained by using for both courses a binding gravel or one which can be compacted without the addition of any bituminous material.

It is probable that a bituminous gravel surface will carry as heavy traffic, and will wear at least as long, as bituminous macadam.

Either bituminous gravel, or sand and oil, can be used with excellent results for resurfacing old water-bound macadam.

SPECIFICATIONS FOR SAND AND OIL LAYER WORK.

The road shall be graded for a width of twenty-one (21) feet in cuts and twenty-five (25) feet on fills. The slopes outside the graded roadway shall be left in a neat condition.

Any clay or other material in the subgrade which, if left, would cause frost action detrimental to the road surface, shall be removed to the depth ordered by the engineer, and replaced with suitable material, and any sandy places shall be hardened as ordered. For this purpose, sandy loam or clay may be used, but if used, only enough of these materials shall be placed on the subgrade to carry the travel while the surface is being formed, and in no case shall the depth of such hardening material exceed three (3) inches after rolling.

The subgrade shall be shaped to correspond with the proposed cross-section of the finished road and shall be rolled with a horse roller, unless otherwise ordered.

On the roadbed prepared as hereinbefore described, asphaltic oil shall be applied for a width of fifteen (15) feet, unless otherwise ordered.

The oil shall be shipped to the nearest railroad freight station in tank cars and transported to the work in suitable distributor carts. It shall be heated in the tank cars or distributor carts, so that when applied it shall have a temperature of not less than 180 degrees fahr. nor more than 250 degrees fahr. The oil shall be applied to the road by a pressure distributor which will spread it evenly over the surface, leaving no spots or streaks uncovered, and no overlapping will be allowed.

The distributor shall be so arranged that the operator can control the flow and can cut out sections so as to vary the width of the road covered.

If two (2) gallons of oil per square yard are to be used in forming the surface, the oil shall be distributed in three applications of approximately two thirds ($\frac{2}{3}$) of a gallon per square yard. If one and one-half ($1\frac{1}{2}$) gallons are used, there shall be two three-quarter ($\frac{3}{4}$) gallon applications.

Immediately after the oil is applied, a uniform layer of sand shall be spread over it, the depth of the sand to be approximately one and one-quarter ($1\frac{1}{4}$) inches for the two-thirds ($\frac{2}{3}$) gallon application, and one and one-half ($1\frac{1}{2}$) inches for the three-quarter-gallon application. Each layer of sand and oil shall be rolled with a horse roller, and if ordered, the road, before its acceptance, shall be rolled with a steam roller. During the rolling, sand shall be applied to absorb any oil flushing to the surface.

Each layer of sand and oil shall be allowed to stand a sufficient length of time so the oil will mix with the sand, and there shall be no surplus sand or free oil on the surface when the next application of oil is made.

The asphaltic oil used shall be as ordered, but in no case shall oil with a viscosity of less than 250 seconds, or more than 600 seconds, Lawrence Viscosimeter at 100 degrees C., be used.

The sand used shall be clean, sharp and free from adventitious materials of all kinds, but if so ordered may contain not over 5 per cent. of clay or loam. It shall contain no stones larger than one-half ($\frac{1}{2}$) inch in their longest dimensions, or more than 30 per cent. passing a 50-mesh screen.

If at any time before the acceptance of the work any soft or imperfect places develop, the material at these places shall be removed and replaced with new material and rolled until thoroughly compacted and until the joints between the new and old work become invisible.

Any inequalities in the surface shall be removed by scraping with a road machine, or other suitable scraper.

After the surface has been completed to the satisfaction of the engineer, and before the acceptance of the work, a light covering of sand shall be spread evenly over the surface.

The surface of the road when completed shall have a crown of one-half ($\frac{1}{2}$) inch to the foot.

No bituminous work shall be done during rainy weather, nor when the weather conditions as to temperature or otherwise are unfavorable for obtaining satisfactory results.

If the oil is furnished by the party of the first part, it shall be delivered in tank cars at the railroad freight station nearest the site of the work. It shall be ordered when and as requested by the contractor, who shall be responsible for any railroad demurrage or other charges incurred, or for any loss or damage to the material which may accrue after its delivery at the railroad station selected.

SPECIFICATIONS FOR MIXED SAND AND OIL WORK.

The road shall be graded for a width of from twenty-one (21) feet to twenty-four (24) feet in cuts, and from twenty-five (25) feet to twenty-eight (28) feet on fills, as ordered by the engineer.

The slopes in cuts and on fills shall conform to lines and grades given, and shall be left in a neat condition.

All clay or other material in the subgrade which, if left, will cause frost action detrimental to the road surface shall be removed to the depth ordered by the engineer and replaced with suitable material. Any sandy places shall be hardened as ordered. For this purpose, sandy loam or clay may be used, but if used, only enough of these materials shall be placed on the subgrade to prevent its being cut up and the sand mixed with the surface during construction.

In no case shall the depth of such hardening material exceed three (3) inches after rolling.

Before the surface is placed, the subgrade shall be thoroughly rolled, a steam roller being used, unless otherwise ordered by the engineer, and the subgrade shall be left with a true surface conforming to the proposed cross section of the finished road.

On the roadbed prepared as hereinbefore described, the sand and oil surfacing shall be applied as follows:

The sand and oil shall be mixed by hand or in a mechanical mixer. If by hand, the mixing shall be done on platforms with rakes and hoes, or by turning with shovels. The platforms shall be made of two (2) inch planks, and shall be about eight (8) feet wide by sixteen (16) feet long, but for convenience in handling may be made in two sections.

If a mechanical mixer is used, it shall have a suitable hot attachment, so arranged that the materials will not be burned during the mixing.

The oil shall be heated in tanks or kettles of a design satisfactory to the engineer, and having a capacity of not less than sixty (60) gallons.

The contractor shall furnish and operate a sufficient number of heating kettles, sand heaters and platforms, if the mixing is by hand, to handle the work expeditiously.

If, in the opinion of the engineer, the work at any time is not proceeding with sufficient rapidity to insure its completion within the time specified in the contract, the contractor shall furnish and operate additional kettles or tanks, sand heaters and platforms, as ordered.

The oil shall be heated to a temperature of from 250 degrees fahr. to 375 degrees fahr., depending on the nature of the oil or oil asphalt used.

The sand when mixed with the oil shall be dry and so heated that a uniform mixture will be secured. Care must be exercised not to overheat the sand so as to burn the oil.

If mixed by hand, the sand shall be spread on the platforms, the hot oil poured over it and the sand and oil mixed with rakes and hoes, or by shovels. If mixed by machine, the sand shall be placed in the mixer before the oil is poured in.

The mixing, whether by hand or machine, shall be continued until all the particles or grains of sand are coated with oil. When the mixing is completed to the satisfaction of the engineer, it shall be transported immediately to and spread on the road. It shall not be dumped directly on the subgrade, but upon dumping boards or iron plates; the dumping boards or plates to be of sufficient size to retain all of the mixture when dumped.

The mixed material after it is deposited in place shall be shaped with rakes and immediately rolled with a horse roller weighing about one (1) ton. The surface shall be shaped with a road machine or suitable scraper and afterwards rolled with a tandem steam roller. The length of time elapsing before rolling with the steam roller shall be as ordered by the engineer.

Any depressions appearing in the surfacing shall be filled with mixed material satisfactory to the engineer. If such depressions are found after the sand and oil have hardened so the new material will not bond readily with the old, a sufficient amount of the old material shall be dug out to allow the placing of not less than two (2) inches of the new mixture, which shall be thoroughly rolled.

Any slight unevenness of the surface shall be remedied by scraping with a road machine or suitable scraper and the surface again rolled.

The sand and oil surfacing shall be eighteen (18) feet wide, four (4) inches thick in the center and three and a half ($3\frac{1}{2}$) inches on the sides after rolling, and shall have a crown of one-half ($\frac{1}{2}$) inch to the foot, unless otherwise ordered by the engineer.

The mixture shall be spread in two courses if ordered. In this case, each course shall be rolled, shaped with a suitable scraper and afterwards rolled with a steam roller, and the top course shall not be spread until a firm and even surface, true to line and grade, is obtained on the lower course.

The oil or oil asphalt used for mixing shall be as ordered, but in no case shall oil having a viscosity of less than 500 seconds, Lawrence Viscosimeter at 100 degrees C., or oil asphalt having a penetration of less than 60, Dow Penetrometer at 25 degrees C., be used.

The amount of oil used shall be as ordered, but in no case shall less than fifteen (15) gallons or more than twenty (20) gallons be used per cubic yard of loose sand.

The sand shall be clean, sharp, fairly coarse and well graded, and shall contain no adventitious material of any kind. It shall contain no stones more than one-half ($\frac{1}{2}$) inch in their longest dimensions, or over 52 per cent. passing a 50-mesh screen.

After the sand and oil mixture has been shaped and rolled to the satisfaction of the engineer, a seal coat of asphaltic oil shall be distributed on the surface in two (2) applications of one-quarter ($\frac{1}{4}$) of a gallon per square yard.

Each application of oil shall be covered with a thin layer of sand spread evenly over the surface and rolled with a steam roller, additional sand being added as needed to absorb any oil flushing to the surface. The asphaltic oil used for the seal coat shall be of a grade satisfactory to the engineer, but in no case shall oil having a viscosity of less than 250 seconds, or more than 600 seconds, Lawrence Viscosimeter at 100 degrees C., be used.

The oil shall be heated in tank cars or otherwise and shall be transported to the work in suitable distributor carts or trucks. It shall have a temperature of approximately 250 degrees fahr. when applied.

The oil shall be applied by a pressure distributor which will spread it evenly over the surface, leaving no spots or streaks uncovered, and no overlapping will be allowed.

The distributor shall be so arranged that the operator can control the flow and cut-out sections, so as to vary the width of road covered.

The sand used for the seal coat shall be clean, sharp and free from adventitious materials of all kinds, but may contain not over 5 per cent. of clay or loam, if so ordered. It shall contain no stones larger than one-half ($\frac{1}{2}$) inch in their largest dimensions, or more than 52 per cent. passing a 50-mesh screen.

The contractor shall sprinkle the subgrade or surface of the road with water, when and as directed by the engineer.

If at any time before the acceptance of the work, soft or imperfect places develop in the surface, the material at all such places shall be removed and replaced with new mixed material, and these sections shall be re-rolled until the new material is thoroughly compacted and the joints between the new and old material become invisible. In repairing imperfect places, the old material shall in all cases be removed to a depth sufficient to allow the placing of at least two (2) inches of the new mixture. If such work is done after the seal coat has been applied, all sections so disturbed shall be resealed. No extra allowance shall be made the contractor for removing and replacing unsatisfactory material.

No bituminous work shall be done during rainy weather nor when the weather conditions as to temperature or otherwise are, in the opinion of the engineer, unfavorable for obtaining satisfactory results.

If the bituminous materials are furnished by the party of the first part, they shall be delivered at the railroad freight station nearest the site of the work. These materials shall be ordered when and as requested by the contractor, who shall be responsible for all railroad demurrage, storage or other charges incurred and for any loss or damage to the materials that may accrue after their delivery at the railroad station selected.

The oil or oil asphalt for mixing shall be shipped in barrels, and the oil for seal coat in tank cars.

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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**SOME MINOR PROBLEMS IN A HIGHWAY BRIDGE
DESIGN.**

By L. M. HASTINGS,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

THE highway bridge at Walden Street, Cambridge, over the main line of the Fitchburg Division of the Boston & Maine Railroad, has a width of 42 ft. between sidewalk railings, and a length between abutment bearings of 61 ft. This bridge, as constructed in 1892, had two main steel plate girders with steel floor beams carrying the floor joists of hard pine. The floor was of 3-in. hard pine covered with 2-in. spruce. The sidewalks were carried on steel brackets.

The railroad here has four tracks and is built on an ascending grade going west. The clearance between the rails and bottom chords of the bridge was only about 15 ft. 6 in. This brought the tops of the engine smokestacks very close to the lower members of the bridge, with consequent rapid loss of metal by the mechanical effect of the blast, besides the chemical action of the smoke and gases upon all exposed surfaces. Various means were tried to protect the more exposed portions of the steel members from these effects. A heavy coating of asphaltic paint, cement mortar held with expanded metal and heavy sheet lead, were tried with only indifferent success. Finally, the por-

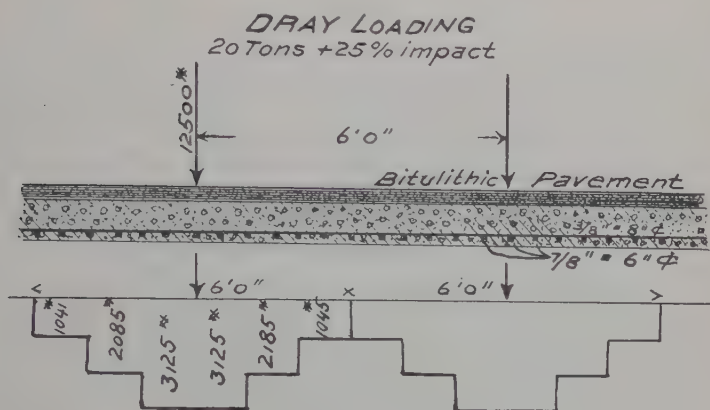
* City Engineer, Cambridge, Mass.

tions of the members exposed to the direct action of the blast from engines were covered with $\frac{7}{8}$ -in. plain oak sheathing held firmly in place with iron clamps, the sheathing first being thickly covered on its upper side with a paste composed of red lead and Portland cement. This was found to work very well, the oak sheathing showing surprising resistance to the destructive action of the blast. Some pieces of oak taken from the bridge after ten or twelve years' exposure showed a loss of not over $\frac{1}{4}$ in. in thickness.

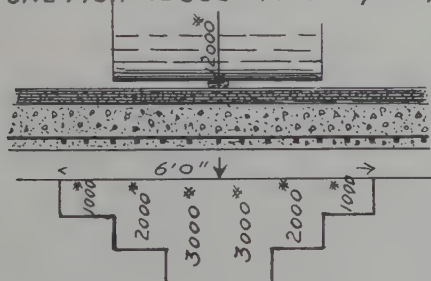
The portions of the metal not so protected were, of course, exposed to the continued action of the smoke and gases and continual repairs were necessary to keep the bridge even fairly safe. The first cost of the bridge superstructure in 1892 was \$3 063.80. The total cost of maintenance and repairs on the bridge from its erection to 1913 was \$3 815.85. In 1913 the bridge had become so weakened that it was declared to be unsafe for travel, and in 1914 it was decided to build a new one in its place.

The new bridge is carried on three main plate girders 63 ft. long and 42 ft. between centers of the two outer ones. The entire floor for roadways and sidewalks is of reinforced concrete slabs carried by steel beams so arranged that no slab shall be of more than eight feet span.

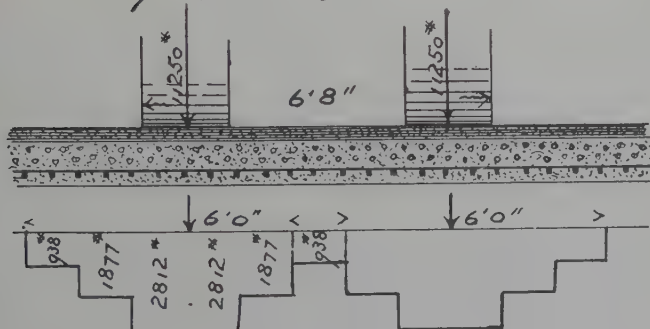
In designing the details of this bridge, two rather interesting problems were encountered. The first related to the distribution of the assumed concentrated live loads upon the floor slabs, from which the proper amount of steel reinforcement could be determined. The slab itself was assumed to be about 9 in. thick and to be covered with a bitulithic pavement about 4 in. thick. The usual live loading for that class of bridge was taken, namely, a four-wheeled dray weighing, loaded, 20 tons, with wheels 6 ft. apart and axles 12 ft. apart, or a steam roller weighing 15 tons with rolls 11 ft. apart, and with 20 per cent. additional for impact and vibration in computing stresses. No data as to the distribution of such loads on the floor slabs under these conditions being available, an empirical assumption had to be made. The conditions of loading producing maximum stress would be as shown on the accompanying diagrams. While it was clear



STEAM ROLLER LOADING
Front Roll 12000 * (No impact)



Rear Rolls Loading
9000 * + 25% on each roll



that the slab had some degree of flexibility and must show deflection under loading, it was assumed that the concrete, bonded laterally by the cross reinforcing rods, would distribute the stresses over a considerable distance. After trying various assumptions for distributing the stresses, the one shown on the stress diagrams was finally adopted.

On the first, it was assumed that the load of 12 500 lbs. was carried equally by the reinforcement on either side of its point of application, and that the influence of one half of this load, or 6 250 lbs., would be extended for a distance of three feet from its point of application in a diminishing amount, and that one half of that amount, or 3 125 lbs., would be carried by reinforcement in the first foot, one third, or 2 085 lbs., in the second foot, and one sixth, or 1 045 lbs., in the third foot, making the entire load to be carried by the reinforcement in a strip of floor six feet wide.

In the second case, the front roll of the steam roller was considered. In this the entire load of 12 000 lbs. was assumed as applied at one point but without the 25 per cent. addition for impact, as it was thought that if impact was produced by the roll, as in passing over a stone, it could be only when the roll was returned to the surface and the load was then automatically distributed by the roll itself. The flexible hanging of the front roll would also assist this distribution. The assumptions for distribution were as before. The greatest load in this case would be 3 000 lbs. per foot.

In the third case, the rear rolls of the roller were considered, and the assumptions as to load distribution were the same as in the first case. The maximum loading in this case would be 2 812 lbs. per foot.

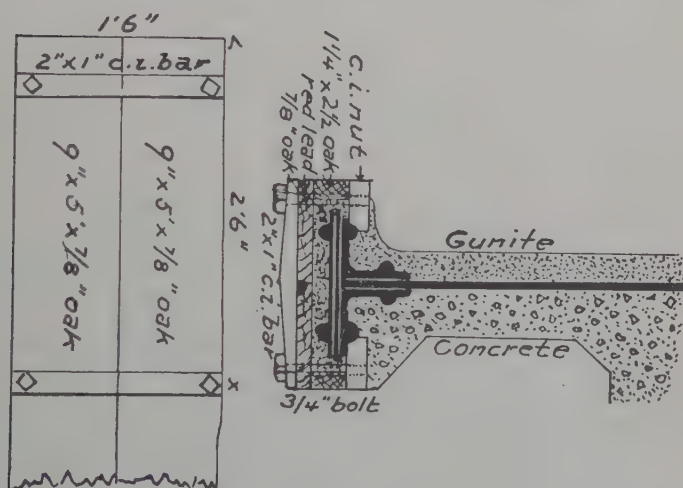
The loading used in determining the amount of reinforcement required was 3 125 lbs. per foot applied in the center of the span.

Before the bridge was completed, the contractors for the paving rolled it with a fifteen-ton roller, passing it repeatedly back and forth over the bridge. The deflection was so small as to be unnoticeable.

The second problem related to the best method of covering

the exposed sides of the two outer girders. They are seven feet high, and to cover them with cast concrete was difficult unless the covering was made rather thick. If the covering was cast thick enough to be practicable, the dead load was greatly increased. It was therefore proposed to use the "Cement Gun" and apply the covering only about two inches thick. When the bids were received, however, it was found that the price de-

DETAIL OF FLANGE COVER



manded for the use of this method was excessive, due to the unfavorable position of the surfaces to be treated over the constantly passing trains beneath. It was suggested that the "gunite" be applied to the girders at the shop after they were fabricated, and that then they might be shipped to the site on the cars. The contractors for the bridge finally adopted and carried out this plan with entire success. The two girders were given a covering of "gunite" in the yard of the shops and were transported on cars to the site and the bridge erected without starting a crack, so far as could be discovered. The "gunite" forms a dense, firm covering which seems to adhere with great tenacity to even the smooth surfaces of steel plate.

Where the railroad tracks pass under any of the main or secondary members of the bridge, the bottom flanges are protected with the oak covering already described, and shown on the accompanying diagram. Twenty-four of these oak coverings, each five feet long, were used on the new bridge.

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PAPERS AND DISCUSSIONS

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PAN-AMERICAN USE OF THE METRIC SYSTEM.

By FREDERICK BROOKS,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

ALMOST every human activity has to do with weights and measures; the matter is one about which men are conservative, and the power of habit makes it hard to bring about changes. From the mass of facts and experiences a few particulars which concern the Boston Society of Civil Engineers are here picked out. This Society officially petitioned Congress, in 1876, praying it to "enact that, after some date to be fixed several years in advance, the metric standards in the Office of Weights and Measures at Washington shall be the sole authorized public standards of weights and measures."

Under date of April 5, 1893, announcement was made in Bulletin No. 26 of the U. S. Coast and Geodetic Survey, signed by T. C. Mendenhall, Superintendent of Standard Weights and Measures, and approved by J. G. Carlisle, Secretary of the Treasury, that

"the Office of Weights and Measures, with the approval of the Secretary of the Treasury, will in the future regard the international prototype meter and kilogram as fundamental standards, and the customary units, the yard and the pound, will be de-

NOTE. This paper will be presented for discussion at a special meeting for which a date has not yet been set.

* 31 Milk Street, Boston.

rived therefrom in accordance with the Act of July 28, 1866. Indeed, this course has been practically forced upon this office for several years," etc.

Dr. Mendenhall stated this in his paper on "Fundamental Units of Measure," prepared for the International Engineering Congress of the Columbian Exposition, 1893, which was printed in the *Transactions of the American Society of Civil Engineers*, Vol. XXX, pp. 120-134. He also stated (p. 130), —

"The most important legislation upon this subject from the founding of the Government to the present time is the Act of Congress of July 28, 1866, legalizing the metric system of weights and measures throughout the United States. It has not been generally recognized that this system is and has been for more than a quarter of a century the only system whose use is made legal throughout the whole country by Act of Congress."

In the third edition (1879) of the "Metric System" by Dr. F. A. P. Barnard, long president of Columbia College, he wrote of what several organizations had done in promotion of the metric reform, saying (p. 321), —

"A few, not limiting themselves to the public expression of their own views, have sought, by correspondence and by gathering and diffusing information on the subject, to operate upon public opinion, and to stir up others to similar action. In efforts of this nature the Boston Society of Civil Engineers has been especially distinguished."

Dr. B. A. Gould, the astronomer, member, for the U. S. A., of the International Committee of Weights and Measures, in addressing the Boston Society of Civil Engineers, March 12, 1890, used the following words, which may well be quoted now (see *Journal of the Association of Engineering Societies* for June, 1890, Vol. IX, p. 289):

"Speaking to a society which has already advocated the introduction of the metric system in a manner and at a time which has insured it a most honorable place in history, and to men whose professional pursuits are constantly tending to impress upon them the importance of the reform, I need say nothing in its behalf. But I am most desirous of using this opportu-

nity to urge upon you that now is the time for renewing an earnest and vigorous effort in its behalf."

It is now nearly twenty years since the Boston Society of Civil Engineers has been canvassed on the question. In the *Journal of the Association of Engineering Societies* for December, 1896, under "Proceedings" (Vol. XVII, pp. 21-2), is the following report, October 21, 1896, from the Committee on Weights and Measures:

"Postal cards reading as follows were sent to each member:

'I am in favor of the passage by the present Congress of an Act requiring the metric weights and measures to be in use by the government departments generally by the beginning of the twentieth century, January 1, 1901.

'I should be willing to have people generally of their own accord adopt metric weights and measures for their ordinary business transactions, and especially for those in which I am myself concerned, at the same time at which the government departments as a whole actually do adopt them.'

"The total number of cards sent out was.....	404
The total number of cards returned was.....	229
Number in favor of both clauses of the card.....	193
Number against both clauses of the card.....	21
Number for first clause and against second.....	2
Number against first clause and for second.....	11
Members in favor of a decimal system.....	2 "

At an earlier date there had been a canvass reported by the Committee on Weights and Measures, along with various remarks in discussion of the subject by a number of members of the Society, which is printed in the *Journal of the Association of Engineering Societies* for July, 1888, Vol. VII, pp. 264-271. Among other things it is stated that there were 57 affirmative replies and 19 negative ones to question (D), — "Is the ultimate exclusive adoption of the metric system throughout the United States desirable?"

In connection with that report is a statement (p. 265) under date of May 26, 1888, of what had been accomplished two days before; thus, —

"Congress has made an enactment (approved by the

President, May 24, 1888) which is likely to be decisive as to the adoption of the metric system in our custom houses. It authorizes the President of the United States to invite the several governments of the republics of Mexico, Central and South America, Hayti, San Domingo, and the empire of Brazil, to join the United States in a conference to be held at Washington at such time as he may deem proper in the year 1889, to consider, among other things, the formation of an *American Customs Union*, and the adoption of a *uniform system of weights and measures*."

In another report of the committee, nearly two years later, the result of that International American Conference (to which the appellation of First Pan-American has often been given more recently) was stated with quotation of the resolution it adopted, as follows (Vol. IX, p. 332):

"That the International American Conference recommends the adoption of the metrical decimal system to the nations here represented, which have not already accepted it."

This was referred to in successive Reports of the Committee on Coinage, Weights and Measures of the House of Representatives in the following language:

"In 1888 (by resolution of May 24) this country invited the republics of Central and South America, Mexico, Hayti, and San Domingo to a conference to be held in the city of Washington, to consider among other things 'the adoption of a uniform system of weights and measures.' The invitation was accepted; the conference was held. To the extent of its power it adopted a uniform system of weights and measures. The other nations, parties to the conference, with scarcely an exception have honorably proceeded to put in force in their respective limits the metric system thus adopted. On what principle of international honor can the United States, the originator of the conference, stand alone in refusing or delaying to abide by its action?" . . . "Having sought the verdict of a tribunal of our own choosing, shall we fail to stand by its decision? A nice sense of honor no less than her own interests would seem to demand from the United States definite and complete action which should put her in full accord on this subject with the nations with which she has so long ostensibly been coöperating." (H. of R. Reports No. 795, 54th Cong., 1st Sess. (March 16, 1896); 2885, 54th Cong., 2d Sess. (Feb. 10, 1897); 1597, 55th Cong., 2d Sess. (June 29, 1898).

Information as to the Second Pan-American Scientific Congress has been kindly furnished by one who took part in it, Elmer L. Corthell, now president of the American Society of Civil Engineers. He has been a member of the Boston Society of Civil Engineers for the last thirty years. The following are the

RESOLUTIONS ADOPTED BY THE ENGINEERING SECTION OF THE CONGRESS,
SUBMITTED TO THE GENERAL SESSION FOR APPROVAL, CONCERNING
THE METRIC SYSTEM.

"Whereas, in the western hemisphere, the English system of weights and measures is in use only in the United States and Canada, while the remaining American republics and the greater part of the eastern hemisphere use the metric system;

"Whereas, the system of measures and weights is an important part of the vocabulary in international relations;

"Whereas, the English system is not nearly as convenient and simple as the metric system is, either in commercial or scientific work;

"Whereas, the use of the English system in the United States is one of the important obstacles to a closer commercial and scientific intercourse and coöperation between the United States and the other of the American republics;

"Whereas, a general change from the English to the metric system in the United States would be a great benefit not only economically but also in promoting international good-will and mutual understanding;

"Be it therefore resolved, that this Congress favors all proper steps and measures to bring about a general use of the metric system of weights and measures in the United States, in the press, in educational and scientific work, in the industries, in commerce, in transportation and in all the activities of the Government."

Verbal amendments being made, the "final Act" included the following (Section V):

"That proper steps and measures be taken to bring about in the American republics participating in the Congress a general use of the metric system of weights and measures, in newspapers and magazines, in educational and scientific work, in the industries, in commerce, in transportation and in all the activities of the different governments."

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DISCUSSION OF THE FEDERAL VALUATION OF THE BOSTON AND MAINE RAILROAD.

BY MESSRS. WM. J. CUNNINGHAM, J. C. IRWIN AND H. V. HAYES.

PROFESSOR CUNNINGHAM.*—I did not come to-night prepared to speak on the subject, but, knowing Mr. Shepherd very well and having some connection with the Boston and Maine, I am very much interested in the subject which he has so very well explained. In fact, it is an admirable treatise on a colossal waste of energy. Looking at it from a broad viewpoint, it is hard to preserve one's equanimity in thinking of an expenditure of fifty or sixty millions which is not going to amount to anything. This equals the gross earnings of the Boston and Maine and Boston and Albany combined, for one year, or the net income of something like fifteen or twenty thousand miles of railroad for one year.

I should like to be as optimistic as Mr. Shepherd is in his statement that this valuation will be the basis of the rates fixed by the Interstate Commerce Commission. In my opinion, there can be but a very remote connection between valuation and rates. The valuation of the Boston and Maine will show undoubtedly that the road, on the basis of its valuation, is entitled to many times the returns which it now is getting. But

* Professor of Transportation, Harvard University.

will that enable the Boston and Maine to increase its rates? What will be the relation of the valuation of its competitors? What effect will the valuation of the Lackawanna Railroad, with its wonderful and costly engineering work, have on the rates between New York and Buffalo in competing with a water-grade line, — the New York Central? Valuation may have some academic bearing on the general scale of rates, but we must underscore the word "academic." I don't think it will have any practical value whatever, and in any event the results of this valuation are going to be so disappointing to the statesmen who fathered the idea that in my opinion the valuation will never be finished and the figures will never be known in their entirety.

The whole thing seems to be a fundamental violation of an engineering principle. An engineer is supposed to get something more than a dollar for the expenditure of a dollar. If the Boston and Maine Railroad could only utilize the splendid services of Mr. Shepherd and his forces in the enlargement of its terminals and the rearrangement of its tracks and laying out new engine houses and other things that would bring in revenue, the road would be very much better off. The chances of the road ever getting a cent out of the cost to make this valuation are very, very slim.

So much for valuation. As a real piece of engineering, — this is academic engineering we are hearing about to-night, — the chairman referred to my little speech last night. At New Haven there is a small railroad club. Last night Mr. Smith, superintendent of telegraph of the New Haven Road, read them a paper on railroad telegraphy and arranged a surprise for them. They didn't know that he had installed in the Hotel Garde a loud-speaking telephone, and that he had arranged with three speakers, including myself, to talk over the telephone from the South Station. That is another branch of engineering, and it is decidedly interesting, to say the very least.

MR. PARKER. — You say the results will be disappointing, and spoke of some of the statesmen who are advocating this. What do you say to Senator La Follette's statement that 70 per cent. of the railroads are over-capitalized?

PROFESSOR CUNNINGHAM. — The valuation will not show that. The forecast shows that the value of the roads, as a whole, is going to be in excess of their capitalization, as a whole. Of course there are exceptions, and it is the exceptional cases we hear the most about. The railroads are not over-capitalized, and that can be shown, I think, very clearly when we know that the capitalization of the average American railroad is something like \$63 000 a mile, while in England it is \$277 000, in Prussia \$116 000, and in France something more than in Prussia. The American railroads are the lowest of any country in capitalization.

MR. PARKER. — You mean the reproduction value would be as great as the capitalization?

PROFESSOR CUNNINGHAM. — I think this whole question is an academic discussion that really will amount to very little. The question is, Is the amount of money represented by the securities in the property? In my opinion, it is going to be overwhelmingly demonstrated by the few valuations which are nearing completion that the capitalization of the roads which are valued are less than the value under any plan of valuation.

MR. PARKER. — I have gathered that, if the railroads would separate their enormous land holdings, the valuation would show a great deal less than their valuation. . . .

PROFESSOR CUNNINGHAM. — The Boston and Maine has no land holdings which amount to anything, but it is safe to say that its valuation will be very much in excess of capitalization. The capitalization of the Boston and Albany is fifty millions. I think that they will have little trouble in finding fifty millions between Boston and South Framingham.

MR. IRWIN.* — As Professor Cunningham says, we do not know how the results of this valuation work are to be used. However, the Valuation Act passed by Congress in 1913 very definitely requires the work to be done.

I am really more optimistic than Professor Cunningham is. In view of present conditions, I believe that the railroads will receive value for every dollar they are spending on the valuation.

* Assistant Valuation Engineer, Boston and Albany Railroad.

Professor Cunningham says he believes that the values in the railroads will more than cover all the securities that are outstanding. So do I, but the American public has to be shown that they will, and I believe that one great purpose of this valuation is to show that there is no further question about it.

Mr. Shepherd's paper is so clear and comprehensive that there is very little to be said regarding methods used in valuation work except as the work on other lines may differ from that on the Boston and Maine.

On the Boston and Albany, the field parties on cross-sectioning and track inventory work were made up mostly of men in the employ of the railroad, the Government merely having a recorder with each party. In this respect the organization differs from that on the Boston and Maine, where the Government furnished the party except the pilot, who was a railroad employee.

Our outside work on grading and track is practically completed at the present time. Before starting the work in the spring, the entire road was chained, and survey parties went ahead of the cross-section and track inventory parties, and maps were prepared for the use of the inventory parties. The work in general was done just as it has been done on the Boston and Maine.

The taking of wash borings for determining the depth of fill in soft places where settlement has occurred has been mentioned. The Boston and Albany had this work done by contract, a Government representative being continually with the outfit to check the results. This work was also valuable in determining the depth of fill in areas where the original surface could not be determined. The results obtained showed, as they did on the Boston and Maine, that the hidden values proven in this way fully warranted the cost of the work. However, the conditions will vary greatly on different roads.

The most interesting case on the Boston and Albany was at Richmond, Mass., west of Pittsfield, where the records showed that there had been difficulty in filling across a big swamp when the road was originally built in 1840, and where settlement has continued to the present time. In this case, with a visible

height of embankment above the surface of the ground of only 18 ft., the total depth of the fill was shown to be 63 ft. As the bed of the swamp was composed of peat, the limits of the sand and gravel fill could readily be determined.

Our office work has differed somewhat from Mr. Shepherd's. Although we used office cars for the headquarters of the field parties and the care of maps and records required by them, our drafting and computing was all done in the Boston office.

In conclusion, I want to say that I consider Mr. Shepherd's paper to be a most valuable addition to valuation literature.

MR. HAYES.*—I want to thank you all for this opportunity of hearing Mr. Shepherd's paper.

I have been with the men employed in inventorying the property of the Fitchburg Railroad during the greater part of the summer, and have noted the great care with which this valuation work was being done. It seems to me that when they get their work done we shall have a very remarkable record, one which has never been had before, of just what the railroads have, just the condition it is in, and just how much property there is in the railroad business. I differ from Professor Cunningham, as I feel that such a record will be of very considerable value, not only to the railroad but to the public.

There is just one thought that has occurred to me. Professor Cunningham says that this valuation is for the purpose of fixing the value of the railroad property. I do not look at it in that way. As I understand it, the order is to find out what it cost the railroads to create this property and also to find out what it would cost to recreate the property at the present time. What the value is, is another and a perplexing question, and I suppose that we shall not be able to know how to find what the value is until we have completed the valuation of practically all the railroads. Then we will know, I hope, by a process of elimination, whether there is to be more than one value of a property; I mean whether there is to be one fair value for rates and whether there is to be another fair value to be used in case of sale. We do not know whether the valuation was ordered by Congress for the purpose of finding a price to be used in case

* Engineer, 101 Milk Street, Boston.

of purchase by the Government, or of establishing a basis for fair charges for service, or simply to know whether the railroads of the country have been over-capitalized or not. At any rate, we will have all the information necessary. We will know what the railroads cost, we will know what it would cost to reproduce them; and between these figures a proper fair value can be found. I have the greatest confidence, from what I have seen of the thoroughness with which the work is being done, that this valuation will be of very considerable value to the country.

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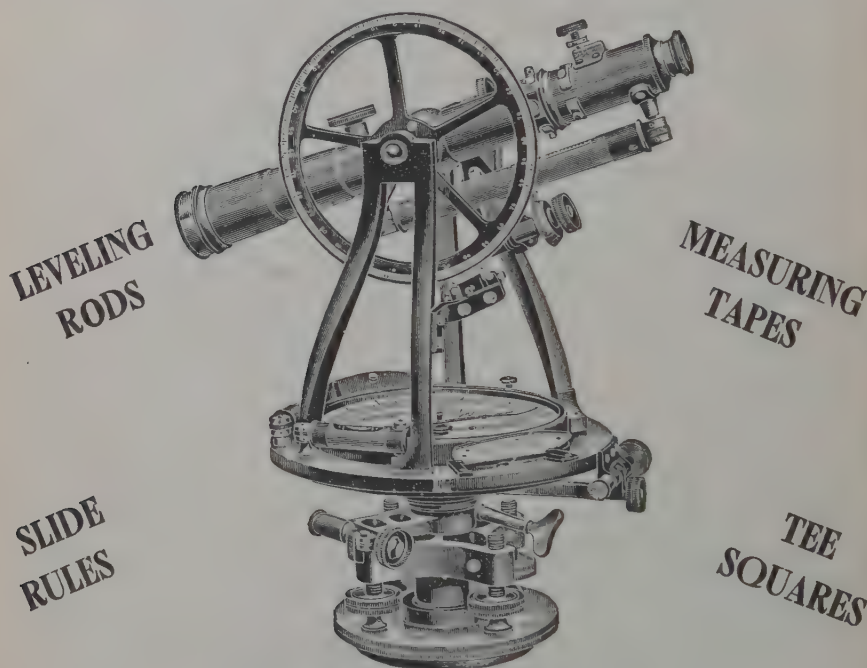
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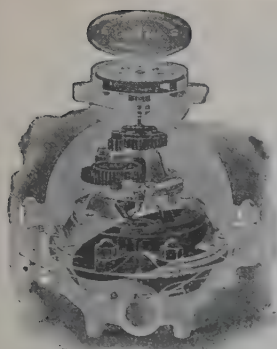
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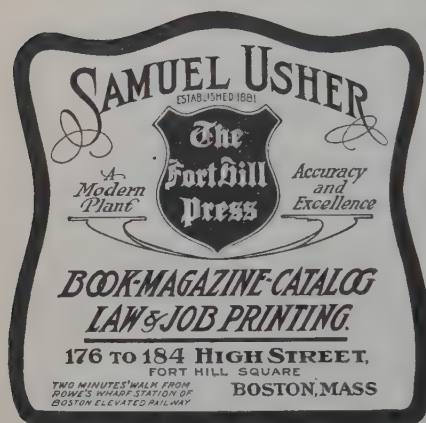
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